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REVIEW ON OIL EXTRACTION TECHNIQUES

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ABSTARCT

Edible oils serve as a major source of meal in diet. The need per person per day is 30 g oil to meet the minimal dietary requirements, whereas, at present, the availability is only 11 g per person per day. India is the largest consumer of edible oils, but lacking in production of oils. So, there is a need to choose appropriate oil recovery methods or improve the present techniques, and also explore the new sources of oilseed materials. This review summarizes all the procedures of vegetable oil extraction.

KEYWORDS: Edible Oils, Oil Recovery Methods, Solvent, Aqueous, Enzymatic & Supercritical Fluid

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INTRODUCTION

Oils are broadly classified into edible and nonedible. Generally, edible oil serves as a major source of meal in diet. Ground nut, mustard, sunflower, soybean etc are the major sources of edible oil. The edible oils are mainly used for cooking purpose and nonedible oils are used in soap industry, drying oil industries including paints, varnishes and plasticizers (Chakraverty, 2017). India is the largest importer as well as the third largest consumer of edible oils. India is lacking in production of oil. The need per person per day is 30 g oil, to meet the minimal dietary requirement, whereas, at present, the availability is only 11 g per person per day (Sahay and Singh, 2015). Higher oil production is mainly depends on the oil content of oil bearing materials, pretreatments and oil recovery methods. There are several oil recovery methods present which include manual, mechanical, chemical methods etc. Researchers reported, "Whichever oil recovery method is engaged, the yield and quality of the oil depends (Ibrahim and Onwualu, 2005). All oil recovery methods have its own significance and constraints. The selection of method can be consider the oil content of the material, production, quality, economic and environmental factors. This review explains different oil extraction procedures.

OIL EXTRACTION METHODS

Five methods can be used to separate the oil from the seeds; organic solvent extraction, mechanical pressing, aqueous, enzymatic, and supercritical fluid extraction (Dunford, 2001).

Mechanical Extraction

In mechanical pressing, mechanical pressure forces the oil out of the seed. The efficiency of this method is low. The main advantages of mechanical extraction are that, it produces solvent/chemical free oil and is a safe process. In addition, the process is relatively simple and not capital-intensive. Furthermore, the operating costs are less than the solvent extraction method (Bachmann, 2001). In large-scale oilseed processing facilities, oil recovery

from high oil content seeds (i.e. canola, sunflower) is done in two stages. The first step is pre-pressing. This process leaves about 15-20% of the oil in the pressed cake, which is then extracted with an organic solvent, hexane (Kemper, 2005). The main advantage of pre-pressing is that the pressed cake formed from the flaked seeds allows good solvent contact and reduces the amount of solvent required for oil recovery. The key to full pressing, also known as high pressure pressing, is to apply maximum pressure to the oilseeds to squeeze out as much oil as possible (Kemper 2005). Low oil content seeds such as soybeans are directly solvent extracted without prepressing.

An oil seed screw press (Figure 1) has a horizontal main worm shaft that carries the worm assembly. The worm shaft revolves within a barrel or cage which consists of axially placed bars (barrel bars) contained within a metal frame. The two halves of the cage are held together by clamping frames. The barrel bars are locked into the cage frames and spaced apart by spacers. The thickness of the spacing between barrel bars is set, depending on the type and preparation of the oilseeds to be extracted; for example, for cottonseed expeller processing, the spacing of the bars in the main barrel may be 0.2 mm in the feed section, 0.19 mm the center section, and 0.2 mm the discharge section (Board, 2002). The main worm shaft and worms are designed to exert a pressure of 69 to 207 MPa on the oilseed that is being processed and, at the same time, to convey the oilseed through and out of the pressure chamber. Different worm shaft configurations may be applied depending on whether the operation is a prepress or full press and the material used (Board, 2002). The screw shaft is designed, so that, the diameter increases from the inlet to the outlet of the barrel while leaving still some clearance between the shaft and barrel, so, the meal can move through the barrel and come out at the end. This increase of the shaft diameter and decrease in the clearance between the shaft and the barrel presses the material against the barrel interior, thus releasing the oil. After the oil is separated from the oilseed, it passes through the barrel bars and is collected in a trough under the screw, and the cake that is too large to exit through the narrow openings on the barrel is extruded through the large openings at the end of the press (Schumacher, 2007).

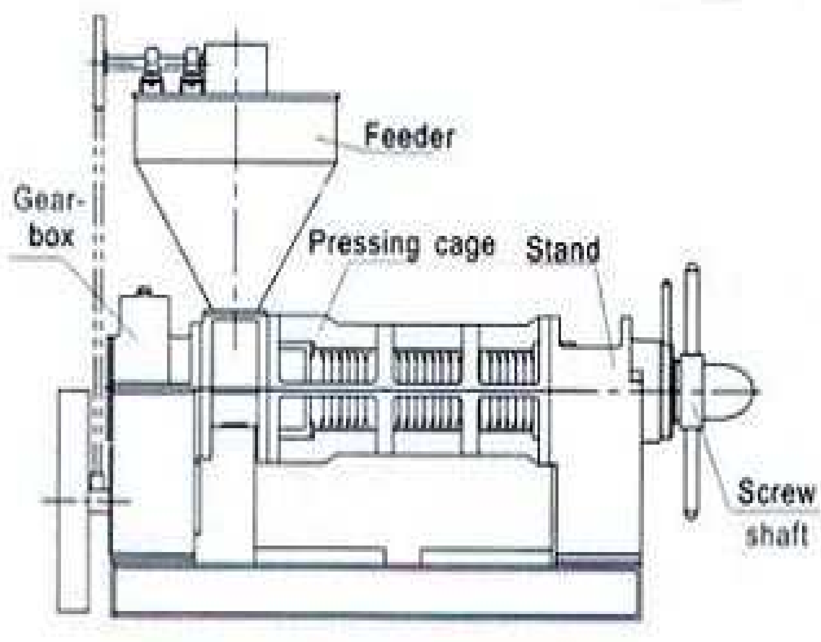

Figure 1: Mechanical Extraction of Oil

The theory of mechanical oil extraction suggests that the oilseed cells must be ruptured by a combination of physical (crushing) and thermal (cooking) pretreatments before oil expression can occur. The process of mechanical oil extraction from oilseeds is started by applying pressure to the oilseed. For mathematical modeling purposes, it is assumed that oilseed is contained within an envelope which retains the oilseed solids, but allows oil to escape across the envelope. During mechanical pressing, oilseed solids are forced to consolidate with the pressure in the barrel while oil flows through the cell wall pores into the inter-kernel voids through which, it flows until it passes through the retaining envelope. This process can be divided into the following components: oil flow through the cell wall pores; oil flow in the inter-kernel voids; and consolidation of the oilseed cake.

Solvent Extraction

Solvent extraction of oil from oilseeds is the most efficient and attractive method for oilseeds having low oil content (Caviedes, 1996). This is the most economical, efficient and widely used process for high oil content seeds (e.g. sunflower, peanut, canola) and also for medium oil content seeds (cottonseed and maize germ). Therefore, vegetable oils are mostly extracted by using solvent extraction (Kemper, 2005). A basic flow chart of solvent extraction process is presented in Figure 2.

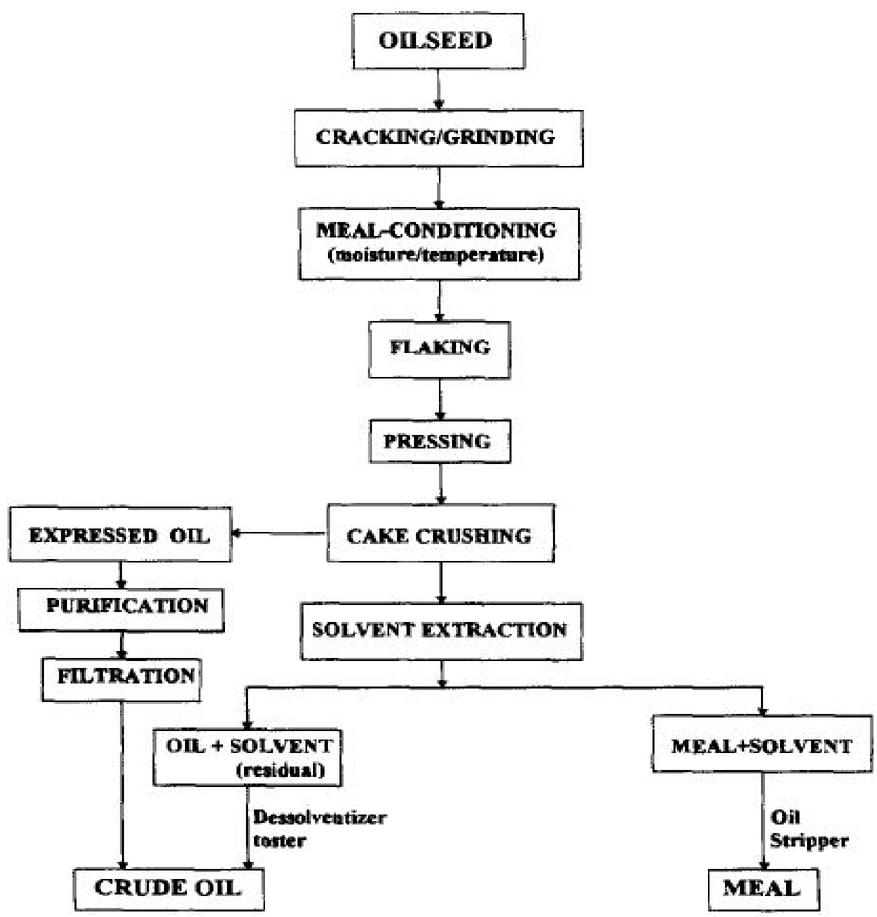

Figure 2: Conventional Oil Extraction of Oilseed Combining Solvent Extraction and Pressing(Rosenthal *Et Al.*, 1996)

Extraction Procedure

The oil containing material is placed inside a thimble, which is loaded into the main chamber of the Soxhlet extractor and then is placed onto a flask containing the extraction solvent. Next connect the soxhlet with a condenser.

Figure 3: Soxhlet Extractor

Heat the solvent contained flask. When the temperature of solvent reaches its boiling point, solvent gets vaporized, travels to a distillation arm and then flows into the thimble chamber. The vaporized solvent gets cooled by condenser and drips into the chamber of extraction unit. When this thimble chamber slowly filled with warm solvent, the oil gets dissolved in solvent and if thimble chamber is completely filled, it is automatically emptied by a siphon arm side by running back down the solvent to the flask. This cycle is allowed to repeat several times for complete dissolving of oil material in the solvent. After extraction, the solvent is eliminated, typically with the aid of a rotary evaporator at boiling point of solvent, yielding the extracted compound i.e. oil. The non-soluble part of the extracted solid remains within the thimble, that's discarded.

Most commonly used solvent is hexane. But, because of the safety, environmental issues and potential health risks, the edible oil industry is in urgent need of replacing hexane-extraction (Bhattacharjee *et al.*, 2006) with some suitable and environment friendly techniques. In 2001, the U.S. Environmental Protection Agency issued strict guidelines for hexane emissions by vegetable oil extraction facilities (EPA, 2001), providing new incentives to develop alternative methods of edible oil extraction, like other bio-renewable solvents as alcohols (Kwiatkowski &Cheryan, 2002) and supercritical fluids (Reverchan, 1994).The use of ethanol as a solvent for the extraction of oil from seeds and grains has for years been considered best for the motive that a excessive degree of solvent efficiency is acquired, and due to the fact, there are produced oil and meal as finished merchandise which might be superior in exceptional to the ones attributable to a hydrocarbon or chlorinated hydrocarbon solvent procedure. However, extracting temperatures ought to be above the boiling element of the solvent, i.e. extraction under pressure, on the grounds that at atmospheric stress ethanol is not an efficient solvent. The operation beneath strain affords a substitute severe hassle, in reference to the introduction of the cloth to be extracted into the extraction system while non-prevent operation is preferred. Pressure device is of extra costly and unsafe than system constructed to function at atmospheric stress. For extraction of oil seeds, an expansion of solvents, along with alcohols, acetone and hexane may be used. However, those organic solvents go away adsorbed residues at the back of and improved temperatures at the desolventization method can purpose chemical transformation of the oleoresins. The solvent residues must be reduced to very small concentrations, generally within the range of 25-30 ppm or less (Reverchan& Macro, 2006).

Aqueous Extraction

The aqueous extraction process was established as substitute to the solvent oil extraction in the 1950s (Rosenthal *et al.,* 1996). It is safe and cheap with simultaneous recovery of oil and protein. The use of water as the cheapest extracting agent is attaining interest, especially with the aim of substituting toxic solvents (Sineiro *et al.*, 1998). The primary precept of this approach, either moist or dry is by way of disrupting the tissue of the material by making use of warmness to allow oil separation. Dry rendering is achieved by heating a material in order that the fats melts out and may be separated (Mc Williams, 2001). Wet rendering is containing three vital processes; material crushing, cooking manner -which at first development is using heated water- and oil separation by using a pressing or centrifuging (Kiple&Ornelas, 2000).

Low quality oil produced and inefficiency in the application of substances are the motives, why this technique was initially useless. The market needs for the much less-processed merchandise and processed with very little chemicals, made this approach rise again (Matthaus, 2008). Many studies had been finished to improve the efficiency of this process. In wet rendering method, the development is accomplished particularly on malaxation remedy (Mc-Williams, 2001). This method produced better yields, however also triggered minor compound damage to the components. Particularly, the use of better temperature led to degradation of flavor and aroma in oil, giving it the heated or burnt odor (Bosselli*et al*., 2009). To tackle this difficulty, methods have been advanced using low temperature processes, where these methods are more often than not used to produce virgin oil appreciated for its excellent (Wong *et al*., 2010).

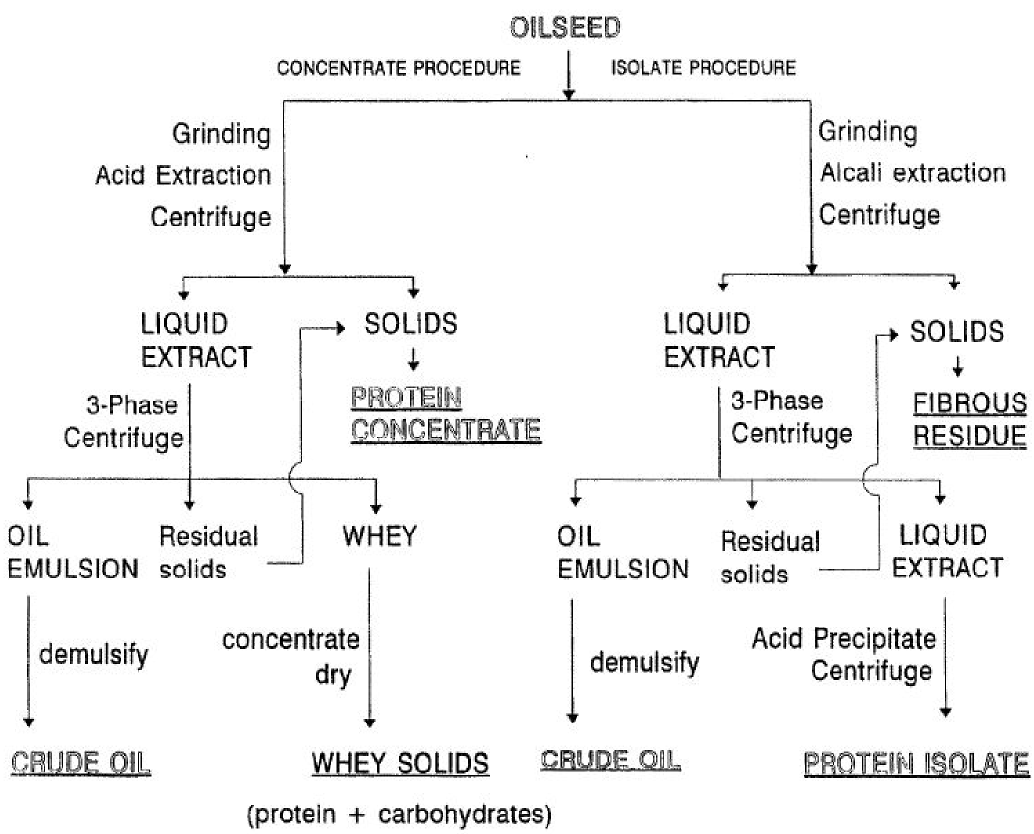

Figure 4: Steps Involved in the Aqueous Extraction Process (AEPI Based on Lusas and Jividen. Two Alternatives Are Given. One result in the Production of Protein Concentrate and The other in the Production of Protein Isolate (Rosenthal *Et Al.,* 1996)

Aqueous Enzymatic Extraction

Aqueous enzymatic oil extraction is an emerging technology in the fats and oil industry. It can be defined as "simultaneous recovery of oil and protein from oilseeds by treating finely ground seeds with enzyme in water and then separating the dispersion by centrifugation into oil, solid, and aqueous phases" (Sharma *et al.,* 2002). Aqueous enzymatic extraction offers many advantages compared to conventional extraction, such as the elimination of organic solvent use and the need for crude oil degumming, lower risk of fire and explosion, and non-toxicity of the solvent used. In addition, high quality end products are obtained. The main limitation of this process is high cost of enzymes used in the process (Rosenthal *et al.,* 1996).

The purpose of using enzymes in oil extraction process is mainly to hydrolyze the the proteins, which form the cell and lipid body membrane of oilseeds. The oil globules are associated with proteins and a wide range of carbohydrates inside plant cells surrounded by a thick cell wall, which has to be ruptured to release the protein and oil. Enzymatic hydrolysis of cell wall is an option for pre-treatment of oilseeds, as it hydrolyses the complex lipoprotein and lipo-polysaccharides molecules into simple molecules, thus releasing extra oil for extraction. Enzyme pre-treatment is considered to be very important, the enzyme selected and its activity must be appropriate to the oilseed cell wall composition. The enzymes most frequently reported in the literature, used for the oil extraction, are cellulase, α-amylase, and pectinase (Rosenthal et al., 1996).

The basic step in the aqueous enzymatic process is mixing the ground seeds with water, before the enzyme is added. At this step, maintaining the pH of the solution is important because, proper pH helps in separating the oil and protein from the liquid or solid phase. The other steps involved in the aqueous enzymatic process include incubation with an enzyme, separation of liquid and solid phases by centrifugation or filtration, and recovery of oil from the liquid phase.

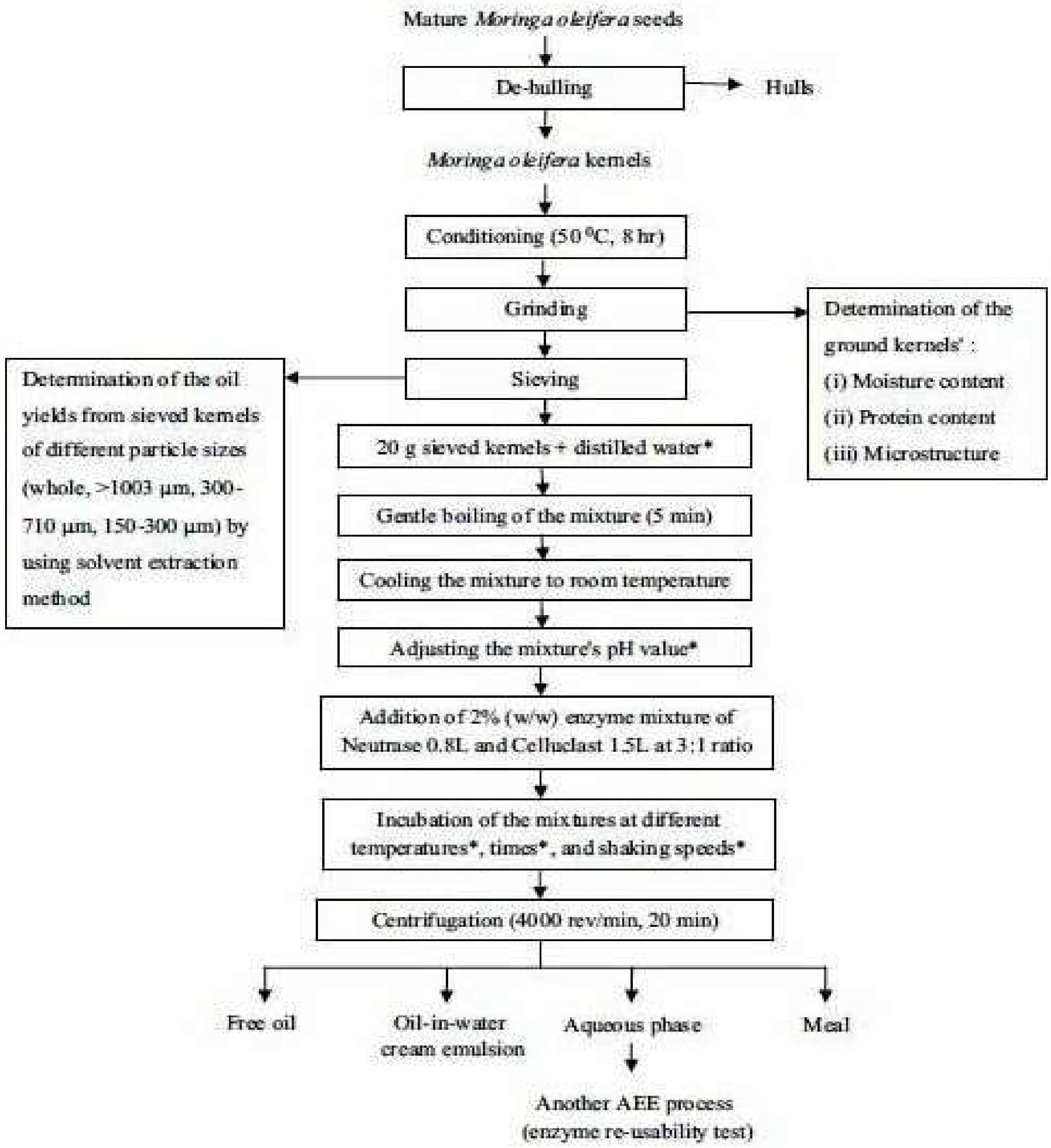

Figure 5: Processes Involved in the Preparation of Moringa Oleifera Kernels, and Extraction of Moringa Oleifera Oil Via Aqueous Enzymatic (AEE) And Solvent Extraction Methods. the (*) Represents The AEE Parameters Tested. (Masni Mat Et Al., 2016)

Supercritical Fluid Extraction

Supercritical fluid extraction (SCE) is a new technique of oil extraction established by using carbon dioxide (Reverchan, 1994). Carbon dioxide is non-toxic, non-explosive, readily available and simply removed from the extracted products compared to organic solvents such as hexane, acetylene etc. This method is also as efficient as solvent extraction at removing triacylglycerides while yielding a high quality, gum-free, and light- colored crude oil (Bargale, 1997).

Extractors are either single-stage or multi-stage static tanks or continuous extractors. The components of a typical extraction unit that uses near-critical CO_2 solvent are shown in Figure 6.

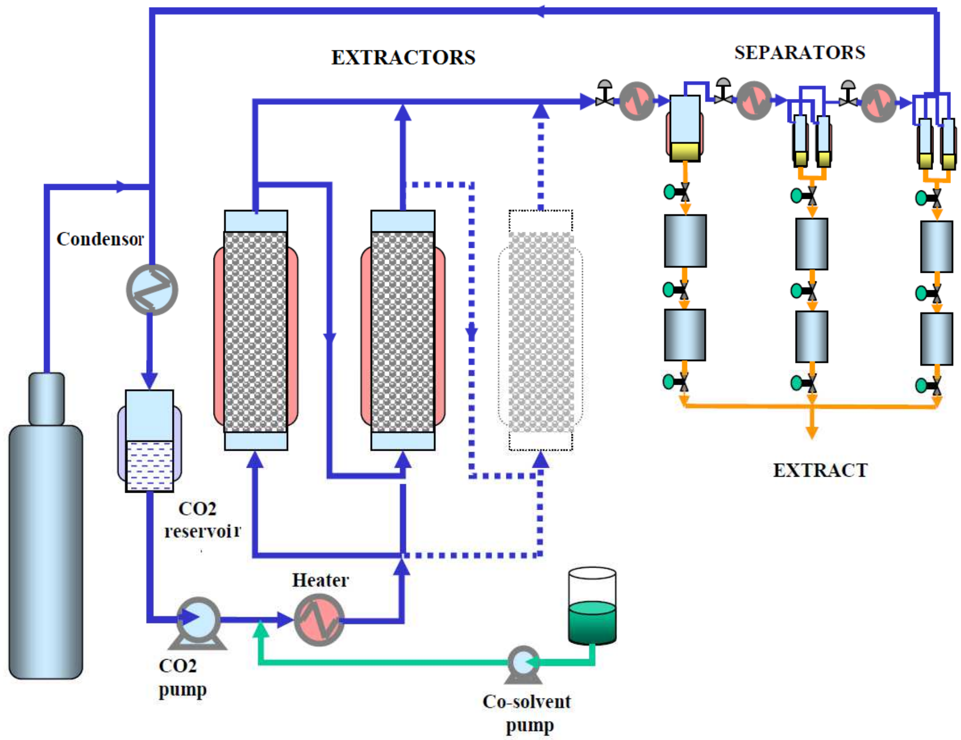

Figure 6: SCFE Processing Unit

The essential components are an extraction vessel, a separation vessel, a condenser and a pump. In supercritical CO_2 extraction, CO_2 is stored as a near-critical liquid in the condenser, and then pumped to the extraction vessel through a heat exchanger by a high pressure pump. The state of the CO_2 in the extractor is determined by the pressure, controlled by pressure relief valve, and the temperature, thermostatically controlled by liquid recirculation through a jacket surrounding the vessel. The material to be extracted is purged with gaseous CO_2 to remove air and then liquid CO_2 is pumped in at a rate that permits a sufficient residence time for equilibrium conditions to be established. The solution is then passed to the separation vessel, in which, conditions are adjusted to minimize the solubility of the extracted components (often by decompression). The CO_2 is then returned to the cooled condenser for re-use and the extract is removed from the separation vessel.

CONCLUSIONS

The vital introduction to both traditional and improved methods for the extraction of vegetable oil from oil seeds has been reviewed. Development of environmentally friendly process has its definite difficulties and challenges. The increase in yield that can be achieved by the methods described previously, is certainly a very suitable solution applied to small industries. However, the use of these methods on large industries will be a dilemma, where the quantity produced is a far comparison to the common method of solvent extraction. The higher cost, especially in enzyme procurement and ultrasound infrastructure pose a significant problem. Even so, as the growing trend of healthy products in which less-processed product such as virgin oil are well appreciated and rewarded with premium prices, this scenario is without doubt an opportunity that cannot be ignored. The increasing public awareness of the environment has also helped to change the paradigm. Buyers these days do not mind paying more for organic and chemical free products. Furthermore, the possibility

of clean production can also be developed due to the possibility to reuse the by-products generated. It was anticipated that some of the new generation of cellulolytic enzymes that are being developed for biomass hydrolysis and fermentation may result in even higher oil yields, and may be more economical to use than the current generation of cellulolytic enzymes.

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